Finding Optimal Independent Grasp Regions of Parallel Manipulators with Additional Applications for Limbed Robot Mobility

Completed Technology Project (2017 - 2021)

Project Introduction

For the problem of robotic manipulation, wherein a robotic manipulator interacts with objects or its environment using an end-effector (gripper), there have been attempts to quantify and optimize how good a hold the gripper has on an object being manipulated using grasp quality metrics. Traditionally, grasp quality analysis assumes a rigid gripper and a rigid object. However, technologies currently being investigated by NASA including climbing robots, robotic transport of surface assets, and robotic grappling of free floating objects rely on compliant grippers, and grippers who primarily apply pulling and shear loads. Of particular interest are microspine and gecko adhesive based grippers currently under development. For such grippers, traditional grasp quality analyses do not apply. The first objective of this proposal is to develop a stiffness based approach to analyze grasp quality accompanied by the theoretical background to evaluate its effectiveness. It is common to use multiple grippers in parallel to perform manipulation tasks. In the case of climbing robot locomotion it is necessary, as each limb/gripper must grasp the surface and work together to move along its trajectory. To accommodate uncertainties, it is desirable to find grasp regions, rather than single grasps, in which the grippers can be placed to achieve their tasks. A novel method for finding such regions is to frame the problem as a bipartite graph problem, where graph edges represent grasp qualities. From this basis, finding grasp regions equates to finding bicliques corresponding to regions of desirable surface geometry. The next objective of this proposal is to develop algorithms for finding regions that are practically useful for grasping, by utilizing and expanding on current graphical and manipulation algorithms. Practical implementations of these algorithms must allow for time-efficient computation of grasps for use in robot planning. The objective is to use techniques including probabilistic methods and example-informed searches to efficiently generate grasp regions that meet or exceed a minimum quality threshold (safety factor) in real time. Finally, it is sometimes necessary to perform in-situ re-grasps. For a climbing robot a grasp may begin to slip, or perform worse than expected, and re-grasping of the surface will be necessary. The objective is to use tools such as in-situ pull testing to detect poor grasps, and develop methods for using this information as feedback to effectively execute a re-grasp. Development of this technology directly impacts NASA interests by supplying methods of analyzing and planning for robot manipulation and climbing robot tasks, thereby advancing crucial technologies for robotic space operations and exploration.

Anticipated Benefits

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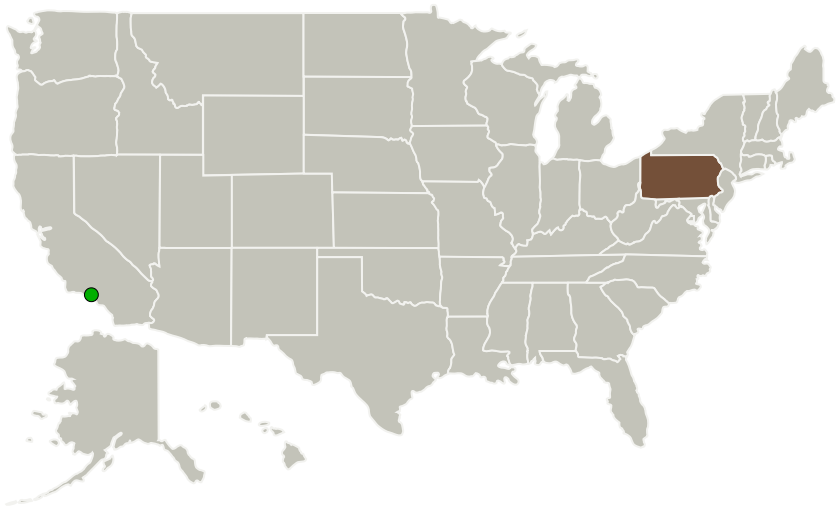
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Carnegie Mellon University	Lead Organization	Academia	Pittsburgh, Pennsylvania
Jet Propulsion Laboratory(JPL)	Supporting Organization	NASA Center	Pasadena, California

Primary U.S. Work Locations
Pennsylvania

Project Website:

https://www.nasa.gov/strg#.VQb6T0jJzyE

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Carnegie Mellon University

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Nancy Pollard

Co-Investigator:

Jonathan M King

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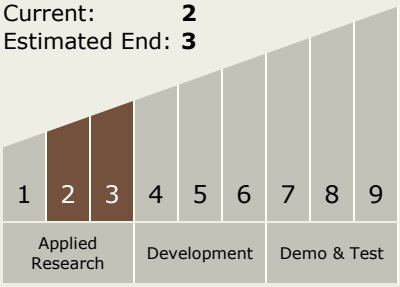
Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX04 Robotic Systems
  - TX04.3 Manipulation
    - TX04.3.2 Grappling Technologies

Target Destinations

Earth, The Moon, Mars